Behaviour of Hybrid Fibre Reinforced Sintered Fly Ash Aggregate Concrete by Replacing Cement by GGBFS

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Abstract - *The main objective of this experimental program is to study the effect of GGBFS on the properties of hybrid fibre reinforced sintered fly ash aggregate concrete. 30% of cement is replaced by GGBFS and the natural aggregates are replaced by sintered fly ash aggregates in different percentages such as 0%, 25%, 50%, 75% & 100%. Steel and polypropylene hybrid fibre combination is used in the experimentation. Steel fibre and Polypropylene fibre are added at (0.5% + 0.5%) by volume fraction.*

Key Words: GGBFS, Steel fibre, Polypropylene fibre, Sintered fly ash aggregates, Hybrid fibre

1. INTRODUCTION

Concrete is one of the oldest and most common construction materials in the world, mainly due to its low cost, availability, its long durability and ability to sustain weather environments. But concrete is relatively strong in compression but weak in tension and tends to be brittle .The weakness in tension can be overcome by the use sufficient volume of certain fibers

The construction field provides numerous contributions to this modern world by many of its modern techniques. Many types of buildings with different technologies are being built all over the world, but construction using concrete is common factor. In all these constructions usage of cement is unavoidable as it is the soul of the concrete. But we all know that the cement manufacture contributes greenhouse gases by producing carbon dioxide

Research in concrete technology has reduced the consumption of natural resources and energy sources to minimize the burden of pollutants on environment. Presently huge amounts of GGBFS are generated in iron industries.

1.1 Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag (GGBS) is a by-product from the blast furnaces used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimize the cementitious properties and produces granules similar to coarse sand. This granulated slag is then dried and ground to a fine powder.

1.2 Sintered fly ash aggregates

Fly ash is finely divided residue, comprising of spherical glassy particles, resulting from the combustion of powdered coal. By heat treatment these small particles can be made to combine, thus forming porous pellets or nodules which have considerable strength. The fly ash is mixed with limited amount of water and is first made into pellets and then sintered at a temperature of 1000° to 1200°C. Sintered fly ash aggregates are one of the most important types of structural light-weight aggregate used in modern days.

1.3 Hybrid fibre reinforced concrete

A composite can be termed as hybrid, if two or more types of fibres are rationally combined in a common matrix to produce a composite that derives benefits from each of the individual's fibres and exhibits a synergetic response. Addition of short discontinuous fibres plays an important role in the improvement of mechanical properties of concrete. It increases elastic modulus, decreases brittleness controls cracks initiation and its subsequent growth and propagation.

2 MATERIALS USED

- Cement

In this investigation Shakti 53S grade cement manufactured by Cement Corporation of India is used. The characteristics of cement are shown in table 1

Sl.no	Characteristics	Values
1	Grade of cement	53-S CCI
2	Specific gravity	3.19
3	Minimum specific surface area	225 cm^2/gm
4	Initial setting time minutes	38
5	Final setting time	2hr 32minutes

Table -1: Characteristics of cement

- GGBFS

GGBFS used in the experiment is obtained from Swarna RMC plant Chalamatti, Hubbli, Karnataka, India. . The physical characteristics of GGBFS are shown in table 2

Table -2: Physical characteristics of GGBFS

Sl.no	Characteristics	Values
1	Specific gravity	2.68
2	Passing sieve size	40 micron
3	Colour	white

- Sand

Natural sand confirming to IS 383-1970 of Zone II is used and it is collected from river Thungbadra, Karnataka, India. The characteristics of sand are shown in table 3

Table -3: Characteristics of Sand

Sl.no	Characteristics	Values
1	Particle shape, size	Round 4.75mm down
2	Specific gravity	2.7
3	Water absorption	1.0%

- Coarse aggregate

Aggregate was collected from crusher at Swarna RMC plant Chalamatti, Hubbli, Karnataka, India. The characteristics of coarse aggregate are shown in table 4

Table -4: Characteristics of coarse aggregate

Sl.no	Characteristics	Values
1	Size of aggregate	20mm and down size
2	Specific gravity	2.67
3	Water absorption	0.5%

- Sintered fly ash aggregate

Sintered fly ash aggregate was collected from Swarna RMC plant Chalamatti, Hubbli, Karnataka, India. The characteristics of sintered fly ash aggregates are shown in table 5

Table -5: Characteristics of sintered fly ash aggregates

Sl.no	Characteristics	Values
1	Specific gravity	1.78
2	Size of aggregate	8-12mm
3	Water absorption	15.8%

- Super-plasticizer

In this experimental work Auracast270M super-plasticizer is used. Auracast270M super-plasticizer is manufactured by Fosroc, Bengaluru, Karnataka, India. The properties of super plasticizer are shown in table 8.

Table -8 Properties of super plasticizer

Sl.no	Characteristics	Values
1	Colour	Light brown
2	Plasticizer	1.069
3	Specific gravity	High performance
4	Chemical admixture	Setting time retarder

- Polypropylene fibre

In this project Recron 3s fibre CT-2424 is used and it is developed after extensive research at Reliance Technology Centre. Recron 3s fibre CT-2424 are brought from Aahana Enterprises, Chamarajpet, Bengaluru, Karnataka, India. The properties of polypropylene fibre are shown in table 6.

Table -6 Properties of polypropylene fibre

Sl.no	Characteristics	Values
1	Material	Polypropylene triangular fibre
2	Type	CT 2424
3	Cut length	12mm
4	Tensile strength	600kg/cm^2
5	Filament diameter	25 Microns

- Steel fibre

In this project work steel fibres was brought from STEWOLS INDIA (P) LTD Nagpur Industrial Estate Kamptee road Uppalwadi, Nagpur, Maharastra. The properties of steel fibre are shown in table 7.

Table -7: Properties of steel fibre

Sl.no	Characteristics	Values
1	Length	60mm
2	Density	7850kg/m^3
3	Tensile strength	8500kg/m^2
4	Specific gravity	7.85
5	Average thickness	0.75mm
6	Type of steel fibre	crimped steel fibre
7	Aspect ratio	80

3. MIX PROPORTION

Mix design of M55 grade of concrete was done as per IS 10262-2009. The mix proportion obtained is as shown in table – 9.

Table -9: Mix proportion

Water	Cement	GGBFS	Fine aggregate	Coarse aggregate
177.3 Ltr/m³	323.40 kg/m³	138.60 kg/m³	714.22 kg/m³	1077.27 kg/m³
w/c 0.382	1		1.54	2.33

4. EXPERIMENTAL RESULTS

4.1 Workability test results

Table 10 gives the workability test results. Variation in workability is represented graphically as shown in fig 1, 2 and 3.

Table10-: Workability test results

% replacement of natural aggregate by sintered fly ash aggregate.	Slump value (mm)	Compaction factor	Vee Bee degree (sec)
0%	12	0.745	35
25%	7	0.741	38
50%	3	0.735	40
75%	2	0.731	44
100%	0	0.700	47

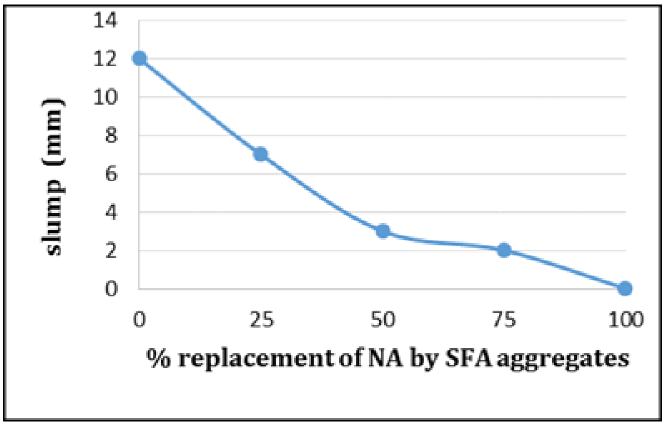

Figure -1: Graphical representation of slump

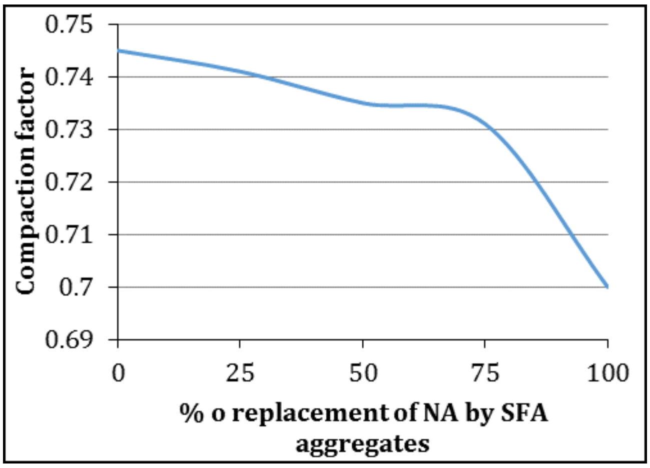

Figure 2: Graphical representation of compaction factor

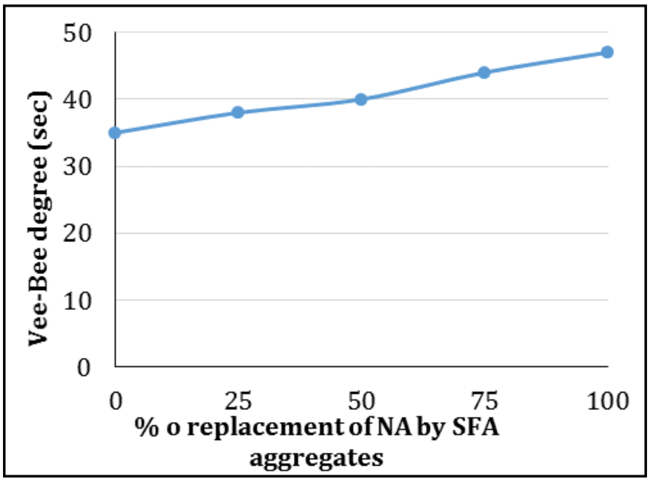

Figure -3: Graphical representation of vee – bee degree

4.2 Compressive strength test results

The results and graphical representation of compressive strength are shown in table 11 and figure 4 respectively

Table11-: Results of compressive strength

% replacement of natural aggregate by sintered fly ash aggregates	Compressive strength (MPa)	% increase or decrease of compressive strength w.r.t ref mix
0% (ref mix)	58.67	0%
25%	48.59	-17.23%
50%	39.26	-33.11%
75%	36.30	-38.16%
100%	28.30	-51.78%

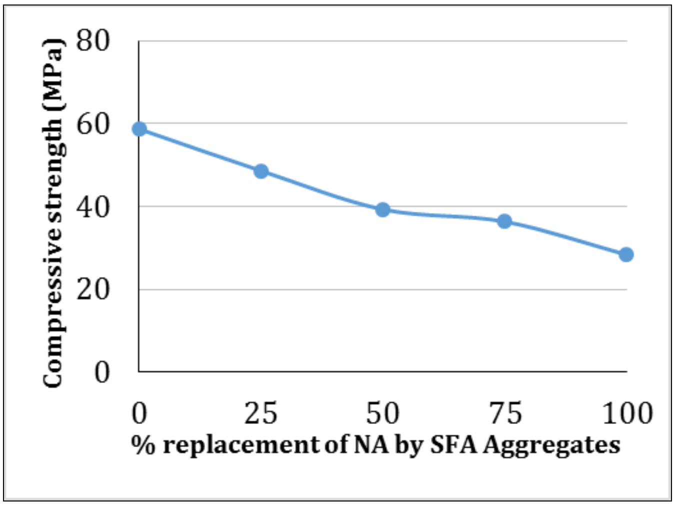

Figure -4: Graphical representation of compressive strength

4.3 Flexural strength test results.

The results and graphical representation of flexural strength are shown in table 12 and figure 5 respectively.

Table 12-: Results of flexural strength

% replacement of natural aggregate by sintered fly ash aggregates	Flexural strength (MPa)	Percentage ncrease or decrease of lexural strength w.r.t ref mix
0%(ref mix)	10.35	0%
25%	9.26	-10.53%
50%	9.11	-10.14%
75%	8.21	-20.67%
100%	7.05	-31.89%

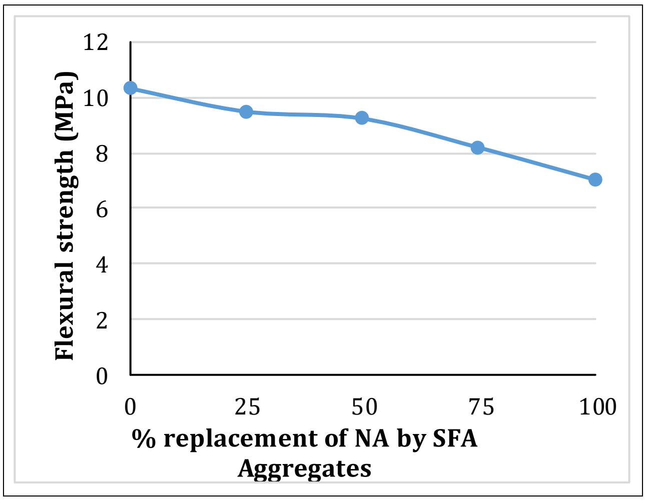

Figure -5: Graphical representation of flexural strength

4.4 Impact strength test results

The results and graphical representation of impact strength are shown in table 13 and figure 6 respectively.

Table 13: Results of impact strength

% replacement of natural aggregate by sintered fly ash aggregate	Impact strength for first crack (N-m)	Impact strength for final failure (N-m)
0% (ref mix)	9177.00	9526.13
25%	8322.00	8642.63
50%	7167.75	7730.63
75%	5322.38	5643.00
100%	2080.50	2308.50

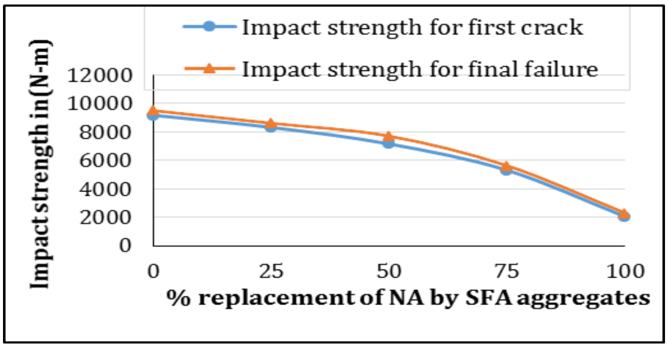

Figure 6: Graphical representation of impact strength

4.5 Sorptivity test results

The results and graphical representation of sorptivity are shown in table 14 and figure 7 respectively.

Table 14: Results of Sorptivity

% of replacement of natural aggregate by sintered fly ash aggregates	Sorptivity $(mm/s^{-1/2})$	Percentage increase or decrease of sorptivity w.r.t ref mix
0% (ref mix)	2.4	0
25%	2.6	8.34%
50%	2.73	13.75%
75%	2.91	21.25%
100%	3.27	36.25%

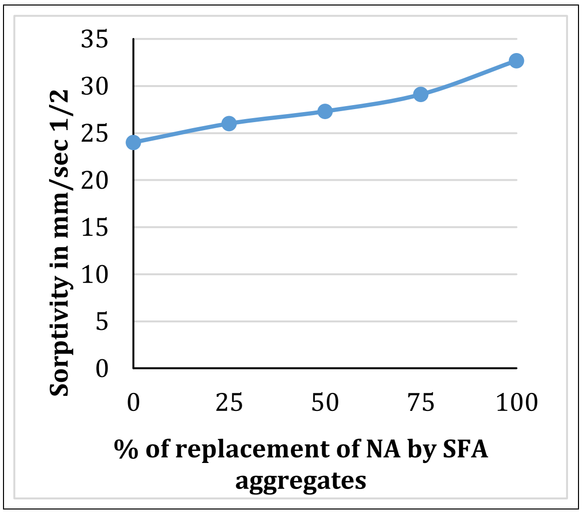

Figure 7: Graphical representation of sorptivity

4.6 Rapid chloride penetration test results

The results and graphical representation of RCPT values in coulombs are shown in table 15 and figure 8 respectively

Table 15: Results of RCPT

% of replacement of natural aggregate by sintered fly ash aggregates	RCPT values (Coulombs)	Percentage increase or decrease of RCPT w.r.t ref mix Value
0% (ref mix)	1716.48	0%
25%	1988.46	13.67%
50%	3593.34	52.23%
75%	3921.30	56.22%
100%	4601.34	62.69%

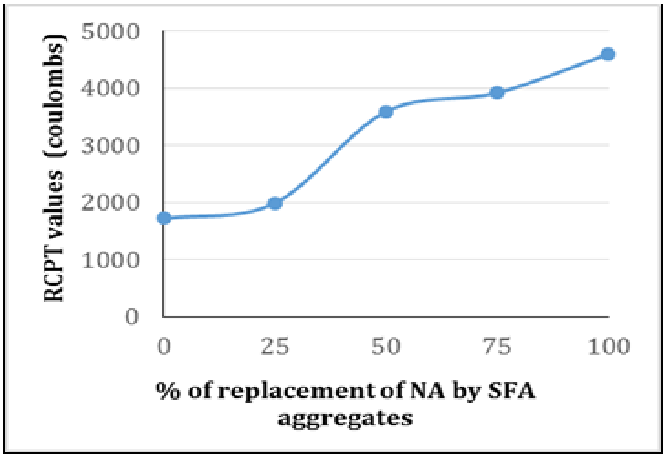

Figure 8: Graphical representation of RCPT values

4.7 Sleeper bending strength test results

The results and graphical representation of sleeper static bending strength are shown in table 16 and figure 9 respectively.

Table 16: Results of static bending strength

% of replacement of natural aggregate by sintered fly ash aggregates	Flexural strength (MPa)		
	Centre	R1	R2
0% (ref mix)	17.65	46.40	46.99
25%	16.91	45.56	45.87
50%	15.68	45.14	44.79
75%	15.22	44.87	44.20
100%	14.21	42.09	42.72

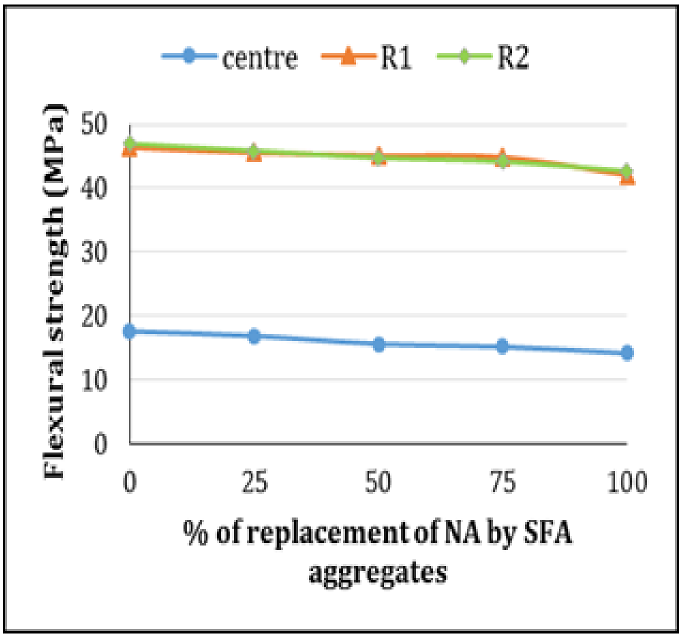

Figure 9: Graphical representation of flexural strength of sleeper

4.8 Energy absorption test results

The results and graphical representation of energy absorption capacity are shown in table 17 and figure 10 respectively.

Table 17: Results of energy absorption.

% of replacement of natural aggregate by sintered fly ash aggregates	Energy absorption (kN-mm)	Ductility factor	Percentage increase or decrease of energy absorption w.r.t ref mix
0% (ref mix)	157.65	2.71	0
25%	152.42	2.42	-3.31 %
50%	148.56	2.24	-5.76 %
75%	145.44	1.82	-7.74 %
100%	138.62	1.74	-11.43 %

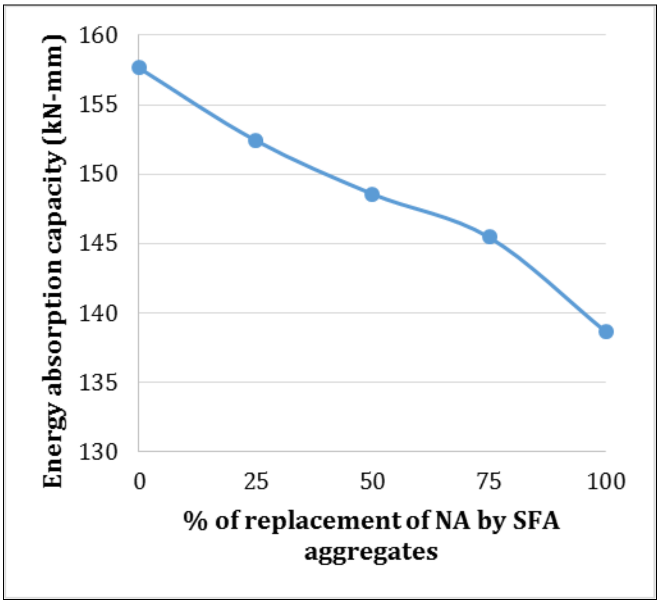

Figure 10: Graphical representation of energy absorption of sleeper

5. CONCLUSIONS

- Workability of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by GGBFS go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates increase.

- Compressive strength, flexural strength and impact strength of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by GGBFS go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates increase.

- Sorptivity of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by GGBFS go on increasing as percentage replacement of natural aggregates by sintered fly aggregates increase.

- Chloride resistance of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by GGBFS go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates increase.

- Flexural strength, Energy absorption capacity and ductility factor of railway sleepers produced by hybrid fibre reinforced sintered fly ash aggregate concrete by replacing 30% cement by GGBFS go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates go on increasing.

- Finally it can be concluded that hybrid reinforced fibre sintered fly ash aggregate concrete with 30% replacement of cement by GGBFS and 25% replacement of natural aggregate by sintered fly ash aggregate may be used to produced quality railway sleepers.

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REFERENCES

[1] Mohankar R.H. , Pidurkar M.D, Thakre P.V, Pakhare S.S. “Hybrid fibre reinforced concrete” International Journal of Science, Engineering and Technology Research, volume-5, issue-1, January 2016

[2] Yogendra O. Patil, Patil P.N, Arun KumarDwivedi “GGBS as partial replacement of OPC in cement concrete – an experimental study” International Journal of Science and Research, volume-2 , issue-11, pp189-191, 2013

[3] Gunasekran M “The strength and behaviour of light weight concrete reinforced with metallic fibres of mixed aspect ratios” International Concrete Journal, volume-49, issue.2, pp-48-55, 1975

[4] Deepa A Sinha, “Strength characteristics of hybrid fibre reinforced concrete”, Global Research Analysis, volume-1, issue-5, pp – 71 – 72

[5] Muntadher Ali Challoob, VikasSrivastava "Effect of GGBFS and steel fibre on Portland pozzolana cement concrete" International Journal of Engineering Research and Technology ,volume-5 number-3 - Nov 2013

[6] Slamet wido, Iman Satyarno, and Sri Tudjono "Effects of hybrid polypropylene-steel fiber addition on some hardened properties of lightweight concrete with pumice breccia aggregates" International Scholarly Research Notices , Civil Engineering, volume -2, article ID 475751, pp 1-8, 2012

[7] Vikrant Vairagade, Kavita S. Kene "Experimental investigation on hybrid fiber reinforced concrete", International Journal of Engineering Research and Applications, volume. 2, issue 3, pp.1037-1041, 2012

[8] Eswari .S "Experimental investigation on flexural performance of hybrid fibre reinforced concrete". International Journal of Research in Engineering and Technology, volume-02 issue-03, June-2015.

[9] Bischoff P. H "Tension stiffening and cracking of steel fibre reinforced concrete" Journal of Materials in Civil Engineering, ASCE, Mach (2003).

[10] Qien Ali ,Vikas Srivastava "Effect of fly ash and steel fibre on portland pozzolana cement concrete", International Journal of Engineering Research and Technology, volume-5 issue-3 - Nov 2013

[11] Abhishek Kumar Singh, Sounthararajan V.M, Anshul Jain and Thirumurugan S. "Evaluation of composite polypropylene fibre reinforced concrete" International Journal of Engineering and Technology, volume-5, issue-2 Apr-May 2013,

[12] IS 456:2000 Indian Standard "Plain and Reinforced Concrete -Code of Practice" (Fourth Revision).

[13] IS 10262:2009 Indian Standard "Concrete Mix proportioning - Guidelines" (First Revision).

[14] IS 516:1959 Indian Standard "Methods of Test for Strength of Concrete" Eighteenth Reprint June 2006 (Incorporating Amendment No 1 and Including Amendment No 2).

[15] "Pre-stressed Concrete" (Fourth Edition-2007) By N Krishna Raju Emeritus Professor of Civil Engineering, M S Ramaiah institute of Technology, Banglore.

[16] "Concrete Technology" (Theory and Practice), M.S.Shetty Head of Department of Construction Engineering, college of Military Engineering (CME), Pune Ministry of Defence.

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